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DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

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Contribution from the Bureau of Entomology, L. O. Howard, Chief.
January 29, 1914.

THE GIPSY MOTH AND THE BROWN-TAIL MOTH, WITH SUGGESTIONS FOR THEIR CONTROL.

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In Charge of Gipsy Moth and Brown-tail Moth Investigations.

INTRODUCTION.

In 1869 a number of egg clusters of the gipsy moth (*Porthetria dispar* L.), a destructive insect pest in Europe, were brought from France to Medford, Mass., by a naturalist who was carrying on experimental work with insects. Later in the season some of the caterpillars escaped, and although none was found in the vicinity during the next few years, enough specimens survived to enable the species to establish itself. In the summer of 1889 this insect became so abundant that fruit and shade trees in the neighborhood were completely defoliated, and the caterpillars swarmed over the trees and into the houses and became a serious nuisance. This resulted in the loss of valuable trees and in the depreciation of property values in that section.

For about 10 years effective work against the gipsy moth was carried on by the State of Massachusetts, and during this period the insect was kept under control. The work was discontinued in 1900, but the species had become so abundant and had caused such widespread injury by 1905 that systematic work was renewed by the State in order to protect the tree growth in the infested area. This work has been continued up to the present time, and as the insect has spread to other New England States it has become necessary to institute more extensive control measures.

In 1906, after the gipsy moth had become established in New Hampshire and Rhode Island, as well as in Massachusetts, an appropriation was made by Congress for suppressing it, and the Secretary of Agriculture was authorized to take all possible measures to prevent its spread. Since that time work has been carried on each year. The area now known to be infested is shown on the accompanying map (fig. 1).

The brown-tail moth (*Euproctis chrysorrhœa* L.) was first found in the United States in Somerville, Mass., during the summer of 1897

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and was undoubtedly introduced some seasons previous to that time on imported nursery stock. The work of preventing damage by this insect was undertaken by the State of Massachusetts soon after the pest was discovered. This species occurs in many sections of Europe and is often seriously injurious. It spreads rapidly because the females are able to fly long distances. The accompanying map (fig. 1) shows the area in New England which is now infested by the

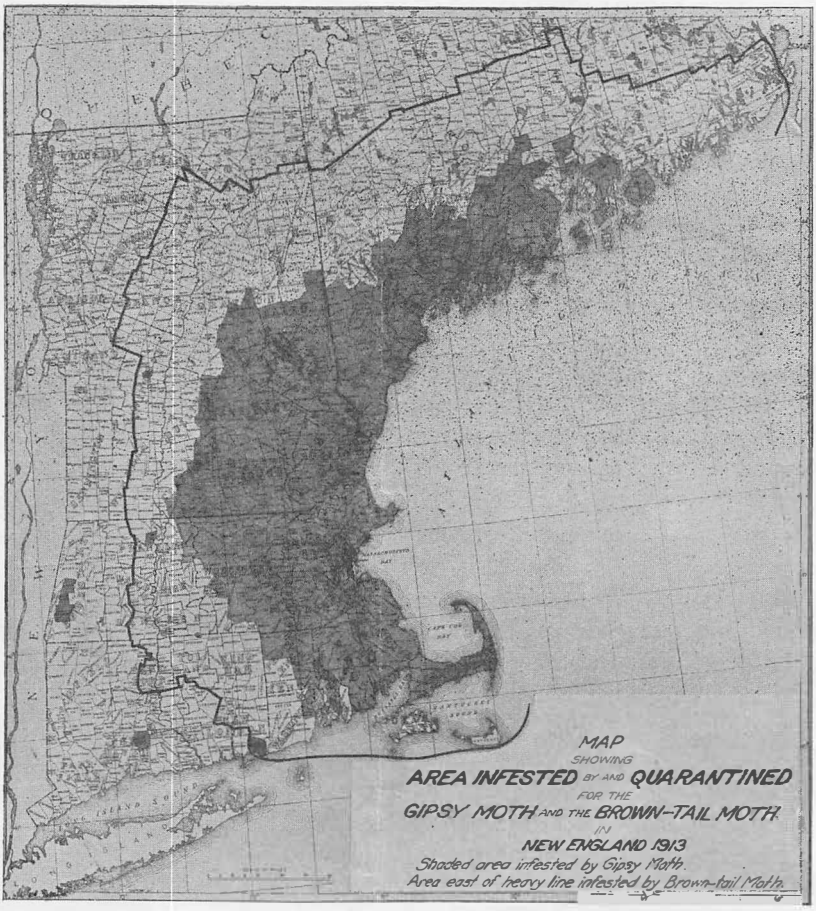

FIG. 1.—Map showing area infested and quarantined for the gipsy moth and the brown-tail moth, 1913. (Original.)

brown-tail moth. Suppressive measures by the New England States and by the Federal Government have been directed against this insect as well as against the gipsy moth.

It is the purpose of this bulletin to give a brief statement of the life history and habits of these two species and to suggest the best methods that can be adopted for their control.

The methods of protecting orchards and the street, park, and ornamental trees in cities and towns are set forth on the following pages, and these methods have been adopted as a result of many extensive experiments. A proper system of orchard management can be adopted which will enable the owner of infested trees to protect them fully without very much expense additional to that required for the control of the other injurious orchard insects. The expense of caring for infested city or park trees is somewhat greater than in the case of infested orchards, but practical methods can be adopted which will not render the cost prohibitive.

The control of these insects in forests is extremely difficult, owing to the small amount of money that any owner can afford to expend in preventing injury to his woodlands. This being so it is usually more satisfactory to have the woodland examined by an expert familiar with the insects and the best measures to be used for their control in order that suggestions for treatment may be made which will be applicable to the conditions in each particular case. Such information can usually be obtained from the State or local officials engaged in gipsy moth and brown-tail moth work, and so far as possible this office will cooperate with owners and give practical advice and suggestions as to the management of their infested premises.

THE GIPSY MOTH.

LIFE HISTORY.

(Fig. 2.)

The eggs.—The female gipsy moth deposits a cluster containing 400 eggs or more, which she covers with buff-colored hair. Most of the egg clusters are laid during the month of July and hatch about the time the leaves begin to appear the following spring. They are deposited on the underside of branches of trees, on tree trunks, under loose bark, or in cavities in the trunks or branches, and are sometimes placed on stones or rubbish and in a variety of situations where they are concealed from view. As the female moth does not fly, egg clusters are seldom found far from the food plant upon which the caterpillars developed.

The larvæ.—The newly-hatched larvæ feed on the opening leaves, making small perforations. They grow rapidly and become full fed early in July. During this period they molt five or six times, and as they increase in size a larger proportion of the foliage is eaten, so that if the infestation is severe, trees may be completely stripped of foliage before the end of June.

The pupæ.—When full grown the caterpillars shed their skin and transform to pupæ, which are chestnut brown in color and provided with tufts of yellow hairs. They remain in this dormant stage for about 10 days, after which the adult insects emerge.

The adults.—The male moth is dark brown in color, with black wing markings, and flies well. The female is white, with black mark-

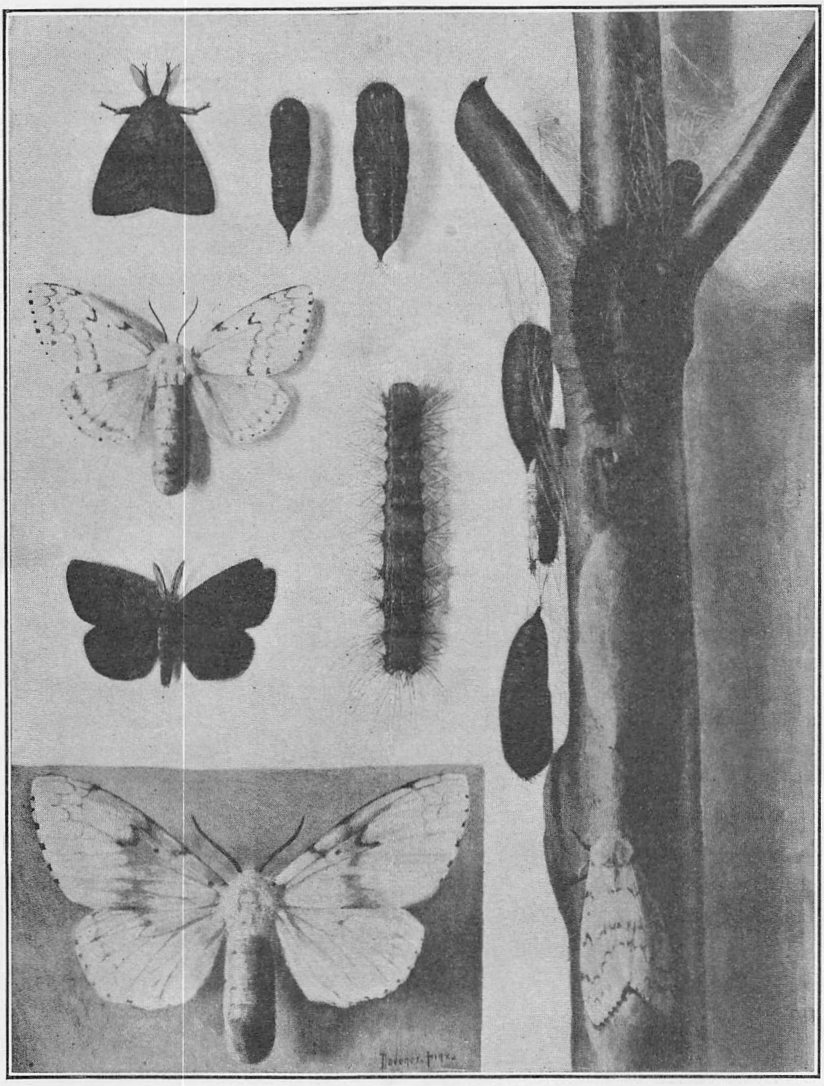

FIG. 2.—Different stages of the gipsy moth (*Porthetria dispar*): Egg mass on center of twig; female moth ovipositing just below; female moth below, at left, enlarged; male moth, somewhat reduced, immediately above; female moth immediately above, somewhat reduced; male moth with wings folded in upper left; male chrysalis at right of this; female chrysalis again at right; larva at center. (Original.)

ings on the wings, and does not fly on account of the weight of the abdomen. After mating the females begin depositing eggs.

FOOD PLANTS.

The most favored food plants of the gipsy moth are the apple, the different species of oak, gray birch, alder, and willow. In cases of bad infestation nearly all of our deciduous trees are injured to a greater or less extent, with the exception of ash. Hickory is not a favored food plant, although the foliage occasionally shows severe feeding. Chestnut will not support the gipsy moth when the caterpillars are in the first stage, and pine will not support the first two stages; but if other food plants are present severe injury may result from feeding by the larger caterpillars. Beech is sometimes fed upon freely, and occasionally the trees are defoliated; and the same is true of poplar.

INJURY CAUSED BY THE GIPSY MOTH.

Unless reduced in numbers by natural enemies, or by the application of control measures, the gipsy moth is capable of causing enormous injury to tree growth. In the area in New England which has suffered most from this insect thousands of trees are dead as a result of defoliation. (See fig. 3.) Apple and oak have been injured most, but pine and other coniferous trees mixed with deciduous growth have suffered severely.

It is undoubtedly true that many oak trees which have been severely weakened as a result of defoliation by the gipsy moth and the brown-tail moth have failed to recover because of the attacks of certain wood-boring insects. The species which has caused the most damage in this way is *Agrilus bilineatus* Web., a beetle the larva of which feeds beneath the bark of injured trees.

NATURAL ENEMIES.

There are few insect enemies of the gipsy moth native to New England that cause any noticeable benefit in reducing its numbers. This is shown by the fact that between the years 1900 and 1905, when no systematic effort was made to suppress the insect, alarming injury resulted, and native insect enemies did not increase to any marked degree. The same is true of the work of native insectivorous birds. While they undoubtedly feed to some extent on gipsy-moth caterpillars, there is no case on record where they have been able to control the species. The wilt disease, which possibly may have occurred in this country for many years, has only recently become sufficiently abundant to be a prominent factor in natural control.

INTRODUCED PARASITES AND ENEMIES.

In 1905 an effort was made by the State of Massachusetts, in cooperation with the Bureau of Entomology, United States Department of Agriculture, to introduce the parasites and natural enemies of the

gipsy moth from its native home in Europe and Japan. Since that time a large amount of parasitized material has been received nearly every year, and as a result some promising natural enemies have become established in this country and are assisting in bringing about the control of the species. The enemies which have become estab-

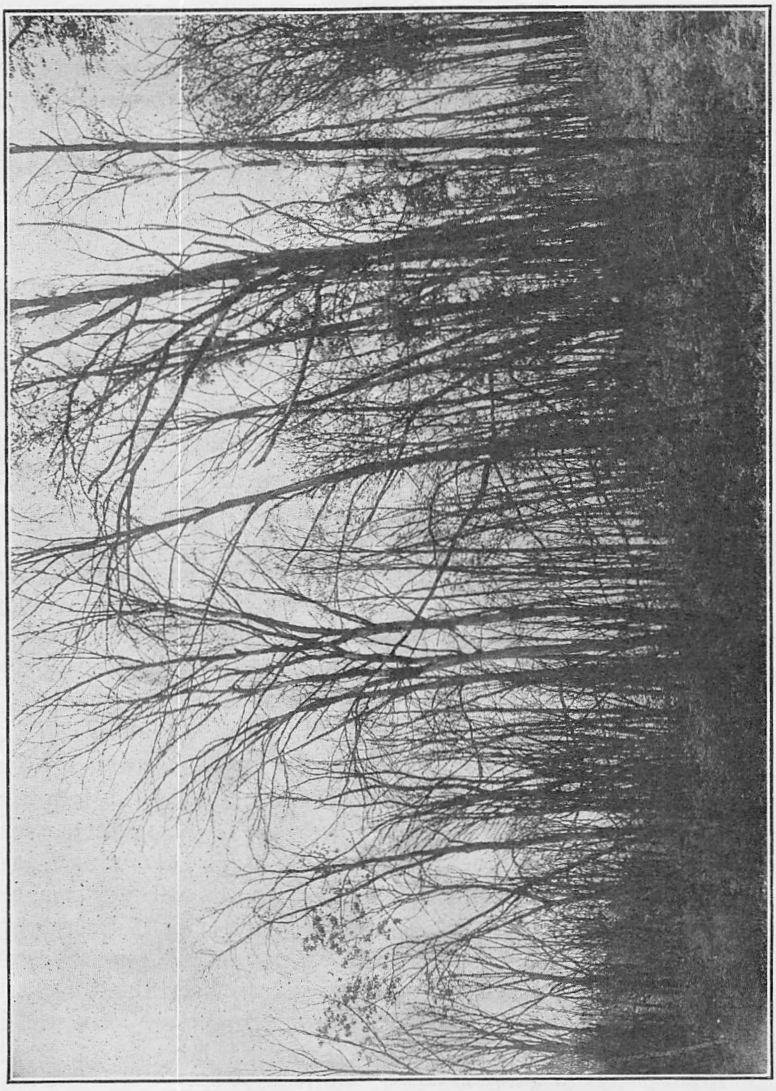

FIG. 3.—Dead and defoliated woodland resulting from gipsy moth attack. (Original.)

lished and are at present destroying the largest number of gipsy-moth caterpillars and pupæ are a Calosoma beetle (*Calosoma sycophanta* L.); a tachinid fly (*Compsilura concinnata* Meig.), which is also a parasite of the brown-tail moth; and a species of Apanteles (*Apanteles lacteicolor* Vier.), which attacks small gipsy-moth and small

brown-tail moth caterpillars. Two species of egg parasites, namely, *Schedius kuvanæ* How., which was imported from Japan, and *Anastatus bifasciatus* Fonsc., which was secured from Europe, have also been colonized in a portion of the infested area and are valuable additions to the natural enemies of this insect.

During the past year the work of the natural enemies of the gipsy moth, including the imported parasites, the Calosoma beetle, and the wilt disease, has served greatly to reduce the numbers of the insect in many badly infested localities. This is particularly true in the region which has been infested longest, and it is hoped that when these enemies of the moth have become established in large numbers over the entire infested territory the insect will be much less a destructive factor than it is at present. Until such time as this can be brought about, however, the most effective hand or mechanical methods of fighting this pest should be continued.

THE BROWN-TAIL MOTH.

LIFE HISTORY.

(Fig. 4).

The eggs.—The female brown-tail moth deposits a small cluster of eggs on the underside of a leaf. These eggs are usually laid in July and are covered with brown hair taken from the body of the female. Hatching begins about the 15th of August.

The larvæ.—The newly hatched larvæ of this insect feed on the epidermis of the leaf and after molting once or twice begin to construct a winter web. This is made by drawing together several terminal leaves and securely fastening them by silk which is secreted by the caterpillars. The larvæ from one or more egg clusters live and feed in common, and as cold weather approaches they retire to the web, in which they remain during the winter. In the spring these larvæ leave the web as soon as the buds begin to develop and feed upon the bud scales and small leaflets. They become full-grown about the middle of June.

The pupæ.—After the caterpillars finish feeding they spin loose silken cocoons and pupate within them. These cocoons are sometimes constructed separately, but in many cases large numbers of them are spun in a single mass. About two weeks are spent in the pupal state.

The adults.—Emergence of the moth usually begins the first week in July. The adult brown-tail moth is pure white in color. The abdomen of the female is much larger than that of the male, but in both sexes the tip of the abdomen is covered with dark-brown hairs. These moths are attracted to strong light, such as electric arc lights, and as they fly at night it is often possible to secure many specimens around the arc lights in cities and towns during the first half of the month of July.

FOOD PLANTS.

The caterpillars of the brown-tail moth commonly feed on apple, pear, plum, oak, and willow, and they are sometimes found in con-

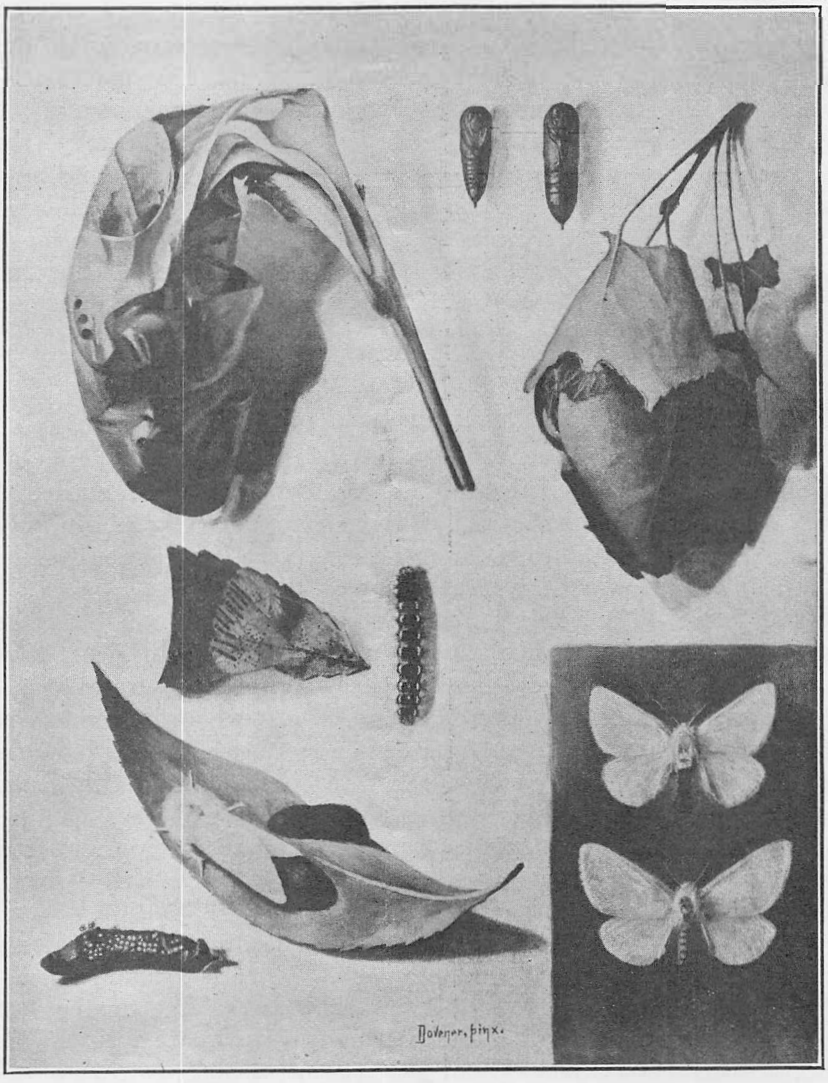

FIG. 4.—Different stages of the brown-tail moth (*Euproctis chrysorrhœa*): Winter nest at upper left; male and female adults, lower right; cocoon in leaves, upper right; male and female chrysalides above, male at left; full-grown larva in center, somewhat reduced; young larvæ at its left; egg mass removed from leaf, showing single eggs, at lower left; female ovipositing on leaf; egg mass also on same leaf. (Original.)

siderable numbers on elm, maple, and rose and in smaller numbers on other common deciduous trees and shrubs. They never attack conifers and are seldom found on hickory, ash, chestnut, or birch.

INJURY CAUSED BY THE BROWN-TAIL MOTH.

The principal injury caused by the brown-tail moth is due to the feeding habits of the larvæ in the spring. If the infestation is bad the caterpillars are often numerous enough to devour the leaves as fast as the trees are able to develop them. As the webs are made on the terminals, the growth of the trees is often severely checked. In

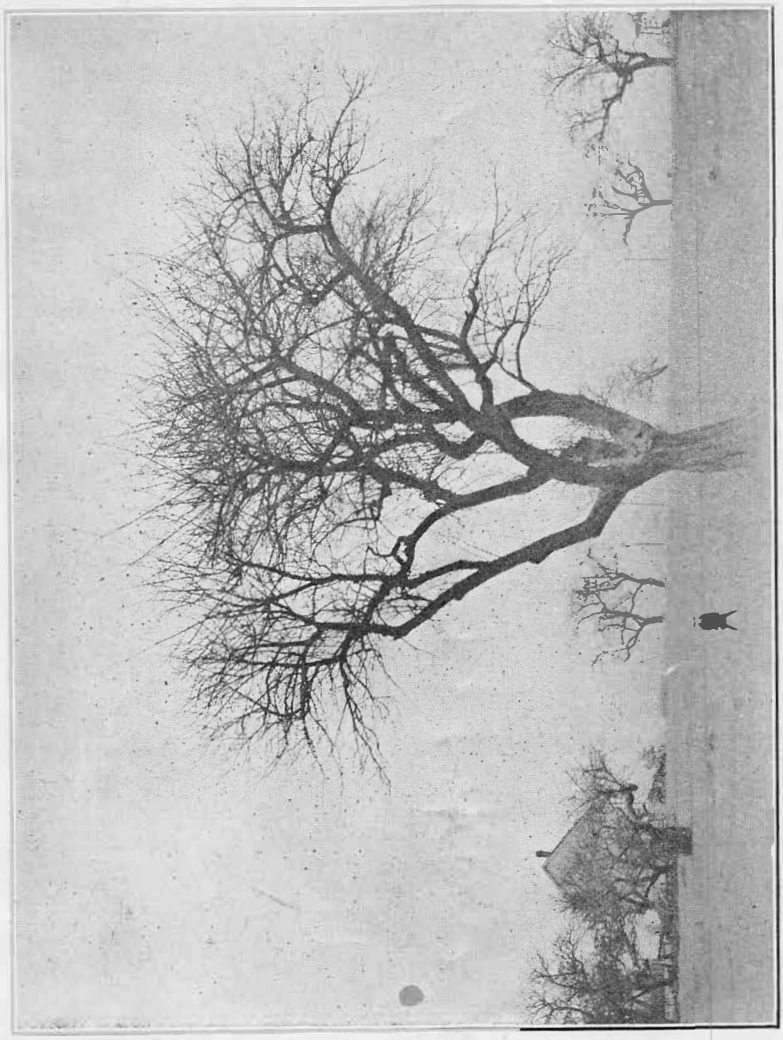

FIG. 5.—Apple trees stripped by brown-tail moth caterpillars. Note old winter webs at tops of trees. (Original.)

severe infestations trees may be completely stripped (figs. 5, 6), but as the larvæ become full-grown during the first part of June, there is usually an opportunity for the trees to refoliate before midsummer. The young larvæ that hatch in August frequently skeletonize the leaves to a considerable extent. This does not damage the trees seriously, as the growing period for the season is nearly completed.

The bodies of the caterpillars of the brown-tail moth are provided with poisonous hairs. A microscopic examination of these hairs shows that the edges are barbed in such a way that when they come

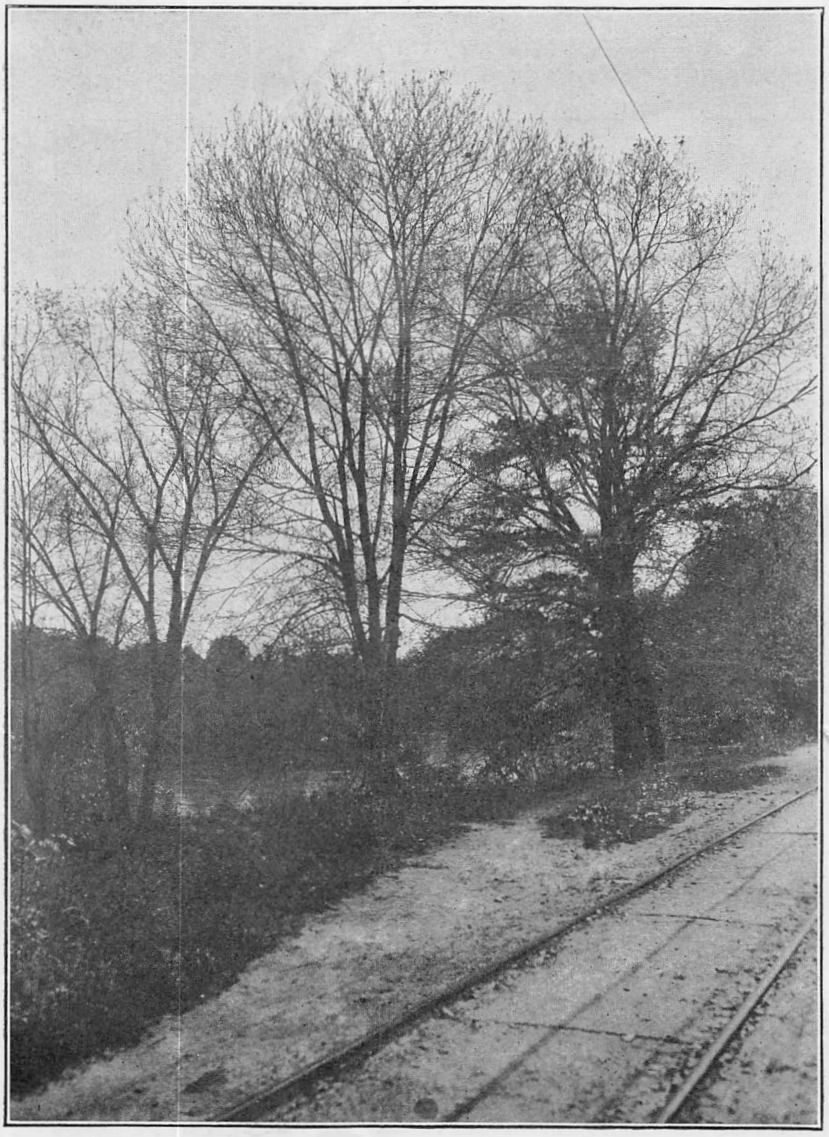

FIG. 6.—Red oak trees stripped by brown-tail moth caterpillers. Note old winter webs at tops of trees. (Original.)

in contact with the human skin and are pressed into the flesh, intense irritation is caused. These hairs are also hollow and contain a poisonous substance which acts on the blood corpuscles. This causes

serious poisoning and severe irritation accompanied with external swelling and is known as the brown-tail rash. There is considerable difference in the susceptibility of persons to this poison, but many cases are reported each year in the infested region, most of which are more serious than those of ivy poisoning. Many camps and summer cottages, particularly in wooded areas, can not be occupied with any comfort during the early summer on account of the poisoning resulting from these caterpillars. If clothing is hung on the line near badly infested trees the hairs frequently find lodgment and are brought into the houses, and later severe poisoning may result.

NATURAL ENEMIES.

One of the most important natural enemies of the brown-tail moth is a fungous disease, *Entomophthora aulicæ*, which attacks the caterpillars, particularly in the spring. It was first reported in this country by Dr. Roland Thaxter in 1888. Like all diseases of this nature, the benefit derived from it is regulated largely by favorable or unfavorable weather conditions. This fungus sometimes works to a slight degree on the small caterpillars in the fall, and in some instances it is found in the winter webs. As a rule, however, the greatest mortality of caterpillars takes place in the spring, when they are nearly full-grown, and the pupæ of the moth may, under the most favorable conditions, be almost completely exterminated. Native parasites and predaceous insects have done very little to check the increase of the brown-tail moth.

INTRODUCED PARASITES AND ENEMIES.

The parasites and enemies already mentioned as being particularly valuable for their work in destroying the gipsy moth also attack the brown-tail moth, with the exception of the egg parasites. The Calosoma beetle, *Calosoma sycophanta*, and its larvæ do valuable work each year in destroying brown-tail caterpillars and pupæ, and the dipterous and hymenopterous parasites also attack this species in considerable numbers. Another imported parasite, namely, *Meteorus versicolor* Wesm., has become established in this country and is doing good work. It attacks the brown-tail moth caterpillars, but not those of the gipsy moth.

In some parts of the infested territory where some of the first parasite liberations were made a marked decrease in the number of moths has been noted during the past two years. The work of the parasites will undoubtedly be more pronounced after they have become more abundant over the entire infested territory.

HAND METHODS FOR CONTROLLING THE BROWN-TAIL MOTH.

The brown-tail moth can be controlled by cutting off the winter webs and burning them before the caterpillars begin to emerge in April. These webs should be destroyed by fire, for if they are simply cut from the tree and left on the ground the caterpillars will emerge and no benefit will result from the work which has been done.

In orchard practice it is sometimes inadvisable to cut the winter webs, for where an infestation is bad it is likely to leave a poorly shaped tree. Spraying in the spring is not a satisfactory remedy unless the infestation is very light, because the caterpillars, when they occur in large numbers, do not allow the tree to put out sufficient foliage to hold the spray material. The most effective method is to spray the trees before the middle of August, using from 6 to 10 pounds of arsenate of lead to 100 gallons of water. Before spraying operations of this sort are attempted care should be taken to determine whether the trees are well infested with egg masses of the brown-tail moth, for if the infestation is very slight it will be more satisfactory to cut and destroy the webs. If the infestation warrants, both shade, ornamental, and fruit trees may be sprayed to advantage at this time. Caution should be used, however, in spraying fruit trees, particularly if early fall varieties are to be treated. If this is to be done a somewhat weaker spray solution may be used, provided it is applied as soon as the caterpillars begin to hatch. The foliage should be treated thoroughly, particularly the terminal shoots, and as much care as possible should be exercised not to cover the fruit. Late fall or winter varieties of fruit may be sprayed in August with arsenate of lead, using 6 pounds to 100 gallons of water, and although an occasional spot may be found on the fruit at the time of picking no injury will result from it. In cases where only a few choice fruit trees are to be sprayed it is practicable to wipe the fruit before packing for sale; but this is not necessary if care is taken to treat the terminal growth of the trees, as this is where the bulk of the egg clusters is deposited.

GENERAL HAND METHODS FOR CONTROLLING THE GIPSY MOTH.

Creosote.—One of the best methods of controlling the gipsy moth is to treat the egg clusters of the insect between August 1 and April 1 with creosote, to which a small amount of lampblack has been added. This mixture is applied with a brush, and it leaves a black residue on the clusters treated. Creosote may be obtained in small quantities from nearly all the large hardware or seed stores in the infested district, where it usually sells for about 35 cents a gallon. If secured in larger quantities a much lower price can be obtained.

Burlap bands.—Gipsy moth caterpillars usually seek shelter during hot, sunny days, and if a band of burlap is attached to a tree large numbers of them will crawl beneath it, where they may be crushed each day. Ordinarily a strip of burlap about 8 inches wide is placed

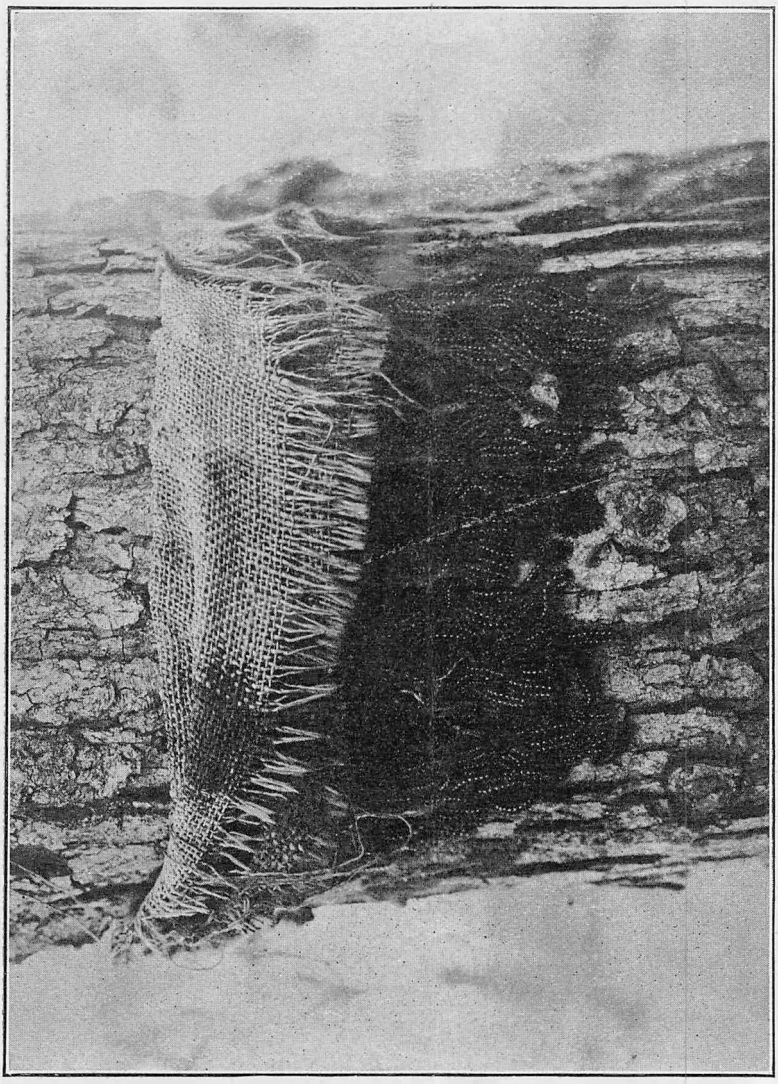

FIG. 7.—Burlap band on tree. The caterpillars beneath it are nearly all those of the brown-tail moth. (Original.)

loosely around a tree trunk and a piece of twine passed around the center and tied to hold it in place. After this is done the top part of the burlap is folded down so that a double shelter is made beneath it. The use of burlap bands has been discontinued to a great extent during the last few years, owing to the expense involved and because

of the fact that if the burlaps are applied early in the season, before the brown-tail caterpillars have pupated, an excellent place is fur-

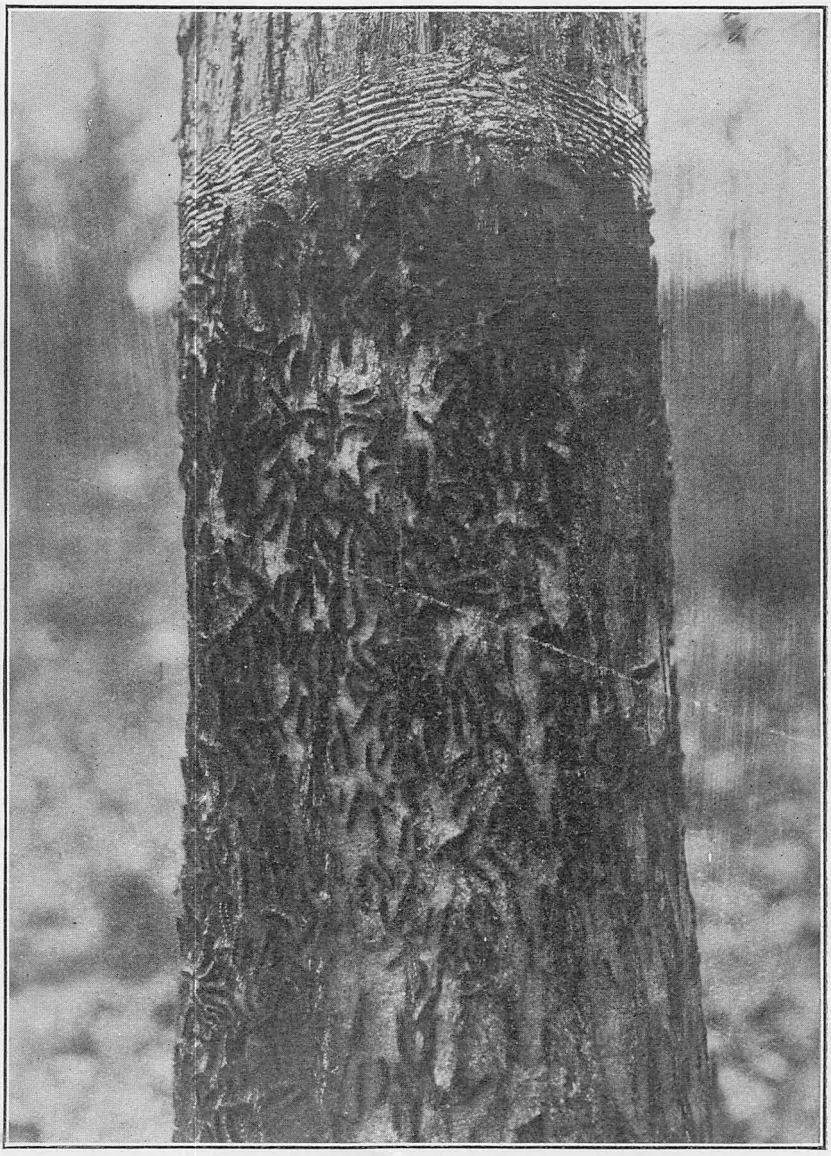

FIG. 8.—Tanglefoot band. Note that there are enormous numbers of gipsy moth caterpillars below the band and on the ground, but none above it. (Original.)

nished for these poisonous caterpillars to make their cocoons (see fig. 7), and severe poisoning results to the workmen. If this method

is to be used at all the burlap should not be attached to the trees until after June 15, when most of the brown-tail caterpillars will have pupated.

Tanglefoot bands.—A band of tanglefoot may be used on tree trunks after the bark has been scraped so that the sticky material can be applied evenly in a thin layer with a paddle. The purpose of this band is to prevent caterpillars from ascending the trees, and if the egg clusters have previously been treated this is a very effective measure. It is necessary every week or 10 days during the caterpillar season to run a comb or other similar implement around the band in order to prevent hardening of the surface and to bring up fresh, sticky material from the part of the band near the bark. (See fig. 8.) Placing these bands on the trees prevents the caterpillars from reaching the foliage; and as the latter usually mass in large numbers beneath the bands, conditions are favorable for wilt disease to develop, and the caterpillars often die in large numbers from this cause and from starvation.

Spraying.—The most effective spray for the gipsy moth is arsenate of lead paste applied to the foliage at the rate of 10 pounds to 100 gallons of water. It is necessary that the treatment be thorough and the application even, if best results are to be secured. For small operations the ordinary orchard sprayer may be used with one or more lines of hose equipped with nozzles of the Vermorel or Bordeaux type. In case large shade trees on valuable park or woodland are to be treated, however, the use of a high-power sprayer is more economical. The type that has given the most satisfactory results in the gipsy-moth work develops sufficient power to throw a solid stream of spray into the trees. The nozzle is constructed so that the stream will break into a fine mist high in the air, and this results in very satisfactory and rapid treatment. (See fig. 9.) With such a sprayer it is unnecessary to climb trees and use small lines of hose, which is a slow and expensive operation. A satisfactory high-power sprayer for this work should be equipped with a 10-horsepower gasoline engine and a triplex pump capable of delivering 35 gallons of liquid per minute at a pressure of from 200 to 250 pounds. This machinery, together with a 400-gallon tank, should be mounted on well-built trucks. One-inch hose is used, and with the outfit mentioned the spray material can be conducted through several hundred feet of this hose without seriously reducing the nozzle pressure, which should be maintained at about 230 pounds.

HAND METHODS TO BE USED AGAINST THE GIPSY MOTH IN ORCHARDS.

The methods to be used for controlling the gipsy moth in orchards should be based largely on the severity of the infestation. If only a

few egg clusters are present in the orchard, early spraying, such as is applied for the codling moth after the blossoms fall, will be found useful, providing the amount of poison used is increased to 10 pounds

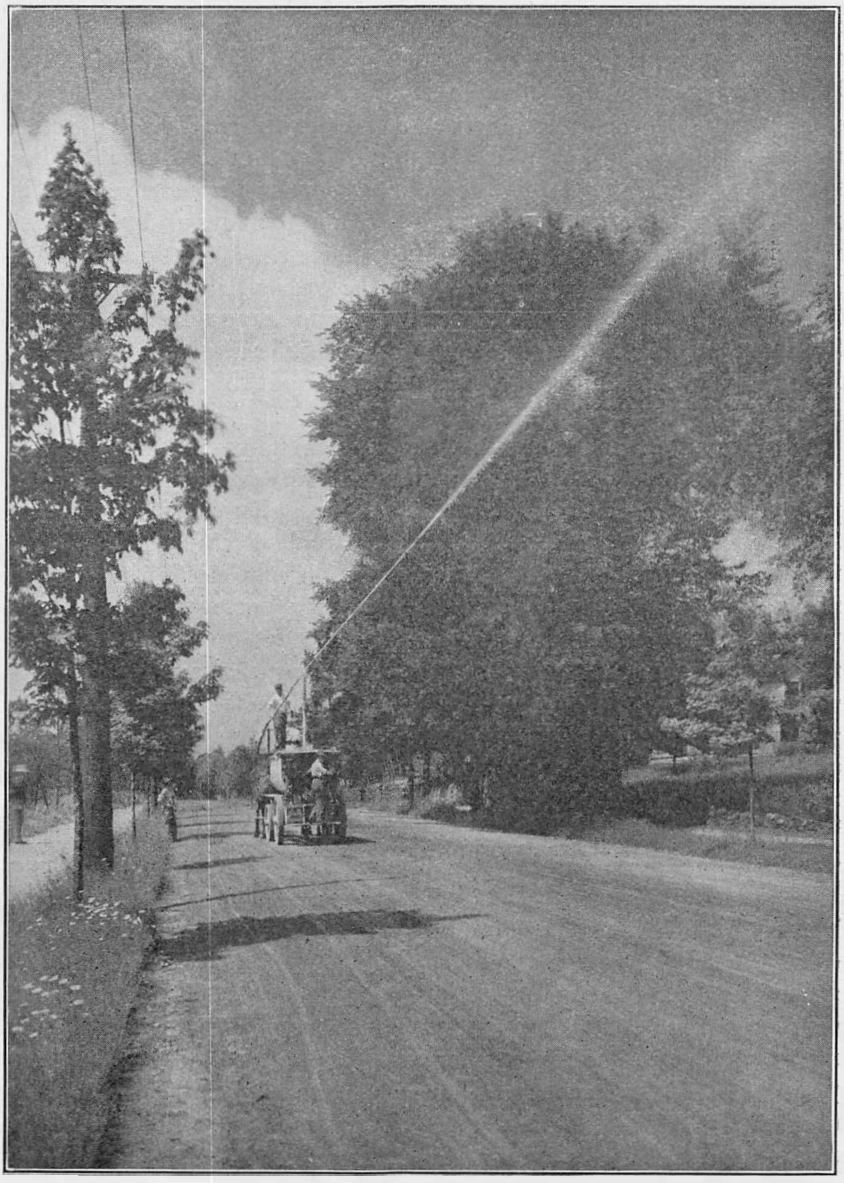

FIG. 9.—High-power spraying outfit in use in treating roadside trees. (From Rogers and Burgess.)

to 100 gallons of water. If the infestation is more serious, a second spraying early in June, using a similar amount of poison, will be found very satisfactory. In cases where the infestation is severe it

will probably be necessary to creosote egg clusters in the winter and spray in the spring if the insect is to be controlled. In any case thoroughness is a prime essential if good results are to be secured.

All poor or hollow trees should be removed, and if badly infested woodland is near by the orchard trees should be banded with tanglefoot. Orchard infestations can be managed by following up these methods, and it will not require much additional expense or a great deal of extra work to protect the trees. In making this statement it is assumed that the orchard is being cared for by up-to-date methods in order to protect it from the codling moth and other injurious insects and diseases, and it is improbable that these results can be brought about in neglected orchards or where the owners do not practice the best horticultural methods in handling their growing trees.

HAND METHODS FOR CONTROLLING THE GIPSY MOTH IN CITIES AND TOWNS.

The same methods that are used in orchards are applicable in cities and towns and for the treatment of park and shade trees. In certain instances it would probably be advisable to use tanglefoot bands or burlap, preferably the former, and to discontinue spraying in cases where the infestation is light or moderate. If the infestation is bad, creosoting, tanglefooting, and spraying should all be used in their season, in order to bring the insect under control and reduce the numbers present to a minimum.

The proper method of handling the gipsy moth in any town, city, or park or on private estates, should be based on the infestation as determined by some one who is familiar with gipsy-moth work, if the best results are to be secured at a minimum expense. Much energy and money may be wasted in applying remedies unless their application is based on a thorough knowledge of existing conditions. An owner of an infested estate should have an examination made by some qualified person who can give reliable recommendations as to treatment. It should be borne in mind that conditions as to infestation vary from year to year, and this should be considered when plans for treatment are being made.

METHODS OF CONTROLLING THE GIPSY MOTH IN WOODLAND.

Satisfactory control of the gipsy moth in woodland by the employment of hand methods such as have already been mentioned is entirely impracticable unless the tree growth is particularly valued for purposes other than lumber. If the woodland is situated near a large city and occupies space that is likely to be utilized in a few years for building lots, considerable money may be expended to advantage in protecting the trees, as these will make the property much

more valuable when the land is subdivided. Limited areas of woodland on private estates may be of sufficient value to the owners to justify a considerable expenditure for moth destruction. In all cases, however, the species of trees involved should be carefully studied before a plan of work is adopted in order that the expense may be reduced as much as possible. Unfortunately the difficulty of treating the woodlands in the infested area of New England is considerably increased by the fact that they are for the most part composed of a variety of species in mixture.

Experiments have shown that coniferous trees are not injured by the gipsy moth if grown in isolated pure stands, and if the growth is such that the trees can be thinned to a stand of conifers no hand suppressive measures are necessary in order to prevent injury by this insect. (See fig. 10.) Such lots will also be immune from attack by the brown-tail moth, as the larvæ of this insect do not feed on conifers.

If mixtures containing a large percentage of deciduous trees are to be protected from moth injury it is very necessary that the species involved should be carefully considered before a decision is reached as to the best methods of treatment. Sometimes practical methods of thinning can be adopted so that species will be left that are only slightly subject to injury by these insects. A limited number of experiments have shown that mixtures of chestnut, pine, red maple, ash, and hickory, regardless of the proportion of each species, are seldom injured by the gipsy moth.

In woodlands the oaks are the most favored food plant of this insect, and unfortunately the infested region abounds in large areas where these species predominate. At present there seems to be no means aside from hand treatment which will prevent serious injury to oak woodland, but as a large part of such land consists of poor sprout growth the amount of damage sustained is not always so great as it might at first appear. The greatest injury likely to be caused in such areas where oaks and gray birch abound is the dying of small seedlings of pine or other valuable species which have been denuded by the caterpillars after the oaks and birches have been defoliated. This leaves the prospective woodland in a much worse condition than it was before the defoliation took place and reduces greatly the chance that the sprout growth will be replaced by any species of value that can withstand gipsy-moth attack. This problem is being given special study and consideration in the hope that some economical method may be devised for protecting and improving wood lots of this character at moderate expense. It is true that there are considerable areas of oak woodland where the trees, although not mature, could be utilized for small timber, railroad ties, or cordwood, and in cases of bad infestation such woodland should be promptly cut if the wood can be sold to advantage. On cheap

cut-over or infested lands in many sections of the territory planting of white pine might be carried on to advantage, but as this involves

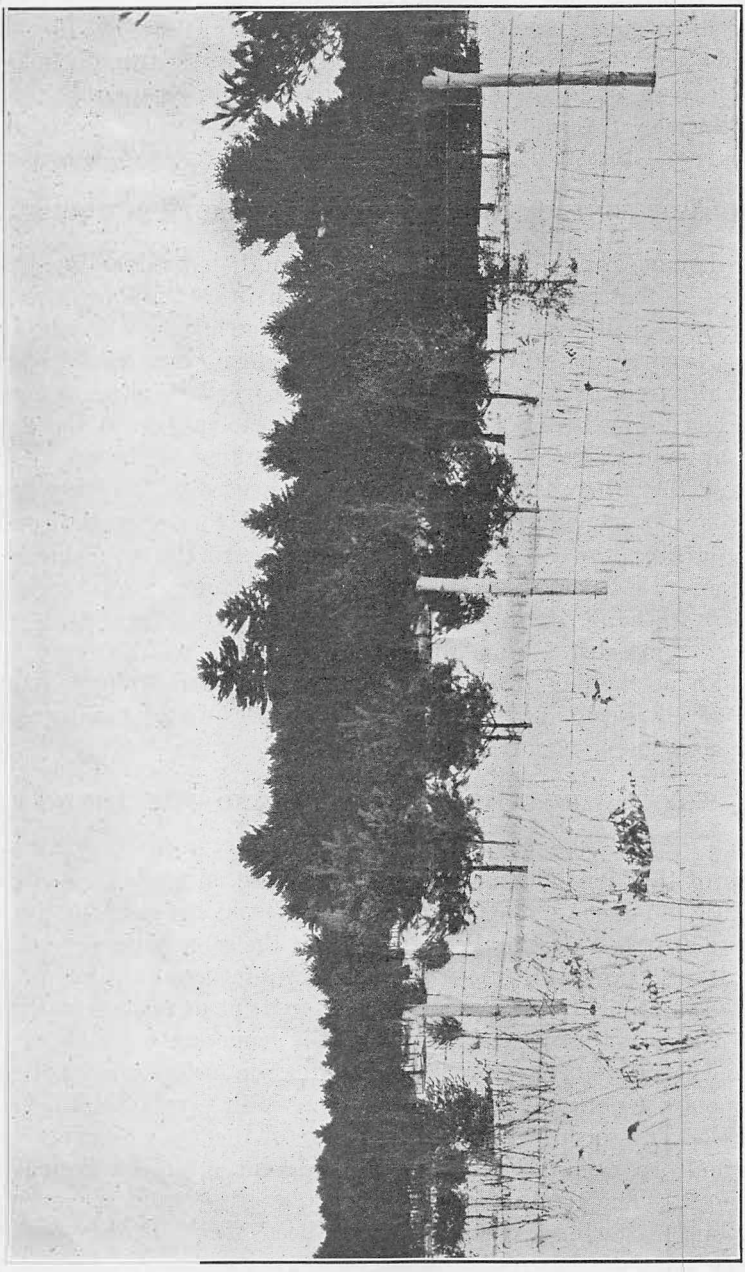

FIG. 10.—Solid white-pine block near Nashua, N. H.: Small trees in foreground were transplanted some years ago. The foliage of this species is not attacked by *small* gipsy-moth larvæ, so it is not injured if grown in clean stands. (Author's illustration.)

considerable expense and as the future crop can not be harvested for a period of years the question as to the desirability of managing

any wood lot in this way must in the end be decided by the owner of the property.

If the practice common in some European countries of maintaining municipal or state forests were well developed in the New England States it would be possible in a period of years to transform considerable areas of land which are now destined to be worthless, and which form a favorable feeding ground for the gipsy moth, into well-managed forests of valuable growth.

METHODS OF CONTROLLING THE BROWN-TAIL MOTH IN WOODLAND.

The damage caused by the brown-tail moth is ordinarily not so severe as is that resulting from gipsy-moth infestation because the former species does not have so wide a range of food plants and, further, because the bulk of the feeding is done early in the season so that the trees have an opportunity to recover before midsummer. In the territory where both insects exist the caterpillars of the gipsy moth supplement the work which is done by those of the brown-tail moth and the injury is therefore greatly increased. The large areas of oak-sprout growth furnish abundant food for brown-tail moth caterpillars, and as a result enormous numbers of the moths develop which migrate each season to the cities and towns and render it necessary for hand suppressive measures to be put in force each year. The area reinfested in this way depends largely on the prevailing winds during the month of July when the moths are flying. Elimination of oak, scrub apple, and wild-cherry trees would assist greatly in reducing the numbers of this pest.

STATE WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

Each of the New England States is carrying on work for the control of these insects. The organization varies, as between the States, owing to differences in local conditions, but the same general methods of work are employed. A brief summary of the conditions of infestation in each State follows, with a statement of any special lines of work that are being attempted and the name and address of the State official in charge. Particular information concerning local conditions may be obtained by communicating with these officials.

Maine.—The work in Maine is in charge of the State commissioner of agriculture, who has authority to appoint a superintendent of moth work. The area badly infested by the gipsy moth is relatively small, but scattering infestations have been found throughout the southern part of the State. The entire area embraces about 4,850 square miles. Infestation by the brown-tail moth covers 12,450 square miles in the State. This species is a particularly serious pest

in the southern part of this territory and causes much injury and financial loss to the famous watering places along the coast. A moderate amount of work is being carried on each year by some of the towns in the infested area, but more should be done since under present conditions the residential sections can not be handled satisfactorily with the amount of funds available. State work is being carried on in the worst infested sections. The superintendent of moth work of Maine is Maj. E. E. Philbrook, Portland, Me.

New Hampshire.—Work in New Hampshire is in charge of a State agent appointed by the governor. Infestation by the gipsy moth throughout the southern part of the State is very heavy, and large areas of woodland have been completely defoliated during the past few years. The total area known to be infested by this insect is 4,960 square miles. The range of the brown-tail moth in New Hampshire is 8,100 square miles, and much loss has been caused during the past few years to the owners of woodland and summer property. Fortunately neither of these insects has become established in any great numbers in the White Mountain section of the State. Many of the towns in New Hampshire are cooperating with the State agent in an attempt to reduce the infestations, and progress in some sections is quite marked. The State agent is also carrying on a series of demonstration cuttings in wood lots in order to induce farmers and others to manage their woodland so as to prevent future moth injury. Prof. W. C. O'Kane, Durham, N. H., has charge of the work.

Vermont.—So far as is known, the gipsy moth does not occur in Vermont, but the brown-tail moth has become established in small numbers in several tiers of towns west of the Connecticut River. The work is in charge of the commissioner of agriculture, who has appointed a field deputy to look after the handling of infestations. The whole area known to be infested embraces about 2,635 square miles. Most of this infestation is recent, and owing to the thorough work done in the spring of 1913 it seems probable that the infested area will be reduced. Mr. E. S. Brigham, commissioner of agriculture, St. Albans, Vt., has charge of the work.

Massachusetts.—Moth work in Massachusetts is in charge of the State forester, but the law requires that each infested town shall appoint a local superintendent, subject to the approval of the State forester, who shall take charge of the work in his locality. The area infested by the gipsy moth in this State is 4,975 square miles. The brown-tail moth infestation covers 6,510 square miles. Each property owner is required by law to expend not to exceed $5 on each $1,000 valuation, and additional work is done in each town and paid for locally. The State appropriation is made in such a way that a certain amount of State funds can be used to assist towns which are most seriously infested or financially least able to bear the burden.

Aside from having general supervision over the entire work in Massachusetts, the State forester takes active charge of suppression work in certain sections of the State where money is subscribed by residents or interested parties for that purpose. Experimental and demonstration work is also being carried on by him with a view to so modifying the forest growth that it will be resistant to moth attack. Prof. F. W. Rane, 6 Beacon Street, Boston, Mass., is State forester.

Rhode Island.—Moth work in Rhode Island is in charge of the State board of agriculture and is placed by it under the supervision of the State entomologist. The gipsy moth infestation covers an area of 450 square miles. Brown-tail moth infestation covers the entire State—1,250 square miles. The gipsy moth infestation is not serious except in the region in and surrounding Providence, but infestation by the brown-tail moth has been worse than usual during the past year. The State entomologist is carrying on suppressive measures over as large an area as possible, but only a limited amount of local work is being done by the towns and cities to prevent injury by these insects. Prof. A. E. Stene, Kingston, R. I., is State entomologist.

Connecticut.—The moth work in Connecticut is in charge of the State entomologist. Only two gipsy moth infestations are known in the State and these have been practically exterminated. The brown-tail moth infestation covers a territory of about 1,475 square miles, and the area has increased considerably during the past year. Careful scouting has been done in all these towns and much thorough work by the State in order to reduce the infestation. At present no system of town or local moth work is in force in Connecticut. The State entomologist is Dr. W. E. Britton, New Haven, Conn.

New York.—A small colony of the gipsy moth was found in Geneva, N. Y., in 1912. Effective work has been done by the State department of agriculture, and the insect is now believed to be exterminated. A close watch will be kept on this locality for several years so that if any of the insects have been overlooked they can be promptly treated. Mr. George G. Atwood, chief horticultural inspector, Albany, N. Y., has charge of this work.

WORK CARRIED ON BY THE BUREAU OF ENTOMOLOGY.

The work carried on by the Bureau of Entomology of the United States Department of Agriculture is designed to prevent the spread of these insects. Owing to the freedom with which the female brown-tail moth flies it is difficult to prevent spread by hand suppressive means, as a heavy migration may take place into new territory during any year when the wind is favorable at the time the moths are flying. The spread of the gipsy moth has been much slower, but infestations are being found in territory along the line of the prevailing winds

when the gipsy moth caterpillars are hatching in the spring. It has been proved experimentally that the caterpillars, immediately after hatching, can be blown long distances, and of course such spread is very difficult of prevention. Fortunately the caterpillars must be active or they will not be caught up by the wind, and no activity is possible unless the temperature is high. From this it results that most of the wind spread is toward the north and northeast, so that the danger of spread by wind to territory outside of New England is not serious at present.

The work of the bureau is being carried on along several distinct lines, namely, experimental work, silvicultural investigations, quarantine work, and scouting work. The experimental work is conducted for the purpose of obtaining information which will serve as a basis for better control methods. It includes a thorough study of the food plants of the insects concerned and of the feeding habits of the caterpillars in their different stages, the rate of increase in the field, the means by which the insects are spread, the introduction and distribution of the foreign parasites and natural enemies of these species, and a study of the wilt disease, which has now become a prominent factor in reducing the infestation in many localities. The last investigation is being carried on cooperatively with the Bussey Institution of Harvard University, and Dr. W. M. Wheeler, who has charge of the economic entomology in that institution, is supervising the technical aspects of the work. A study is also being made, in cooperation with Dr. A. D. Hopkins, who has charge of the Forests Insect Investigations of this bureau, of the secondary insects which attack defoliated trees.

Silvicultural investigations are being carried on in cooperation with the United States Forest Service. Mr. G. E. Clement has been assigned from that service to this bureau for the purpose of conducting experiments to determine whether better silvicultural practices and improved methods of forest management can be employed as a help in checking the spread of these pests.

The entire infested area—15,235 square miles occupied by the gipsy moth and 32,420 square miles occupied by the brown-tail moth—has been placed under quarantine by the Federal Horticultural Board, and shipments of nursery stock, lumber, cordwood, and other forest products are not permitted to leave the territory unless they have been inspected and are accompanied by a certificate stating that they are free from infestation. This work is designed to prevent the spread of the insects for long distances and is being administered by Mr. D. M. Rogers.

The scouting work consists in making examinations in the towns outside the infested area and is directed by Mr. L. H. Worthley. This

work serves to establish the quarantine line. It is the policy of the bureau to carry on as much work as possible in the territory along the western border, for the purpose of stamping out new colonies that may become established and to prevent, so far as possible, further spread of the insect in this direction. A large number of men are employed on this work, and all the towns along the border were given attention this year from Lake Winnipesaukee on the north to Narragansett Bay. The work is carried on with special reference to the gipsy moth, as it would be impracticable to attempt control of the brown-tail moth in this way.

COOPERATIVE WORK.

Since work on the gipsy and brown-tail moths was begun by this bureau a greater or less amount of cooperative work has been carried on with the States concerned. As previously stated, the attempt to introduce parasites and natural enemies of the gipsy moth was conducted cooperatively with the State of Massachusetts for several years. Recently this entire line of work has been managed by the bureau, it being really a problem in which all the States concerned are vitally interested. During the past year Maine and New Hampshire have assisted in the work of collecting parasitized material and liberating it within their borders. The field work and the quarantine work is also carried on to a greater or less degree by means of cooperative arrangements with the States concerned, and since the work was first begun the relations with the various States have been very friendly and harmonious. Parasites have been liberated in greater or less numbers in all of the New England States.

THE OUTLOOK.

During the past season conditions in the oldest infested area have not been as serious as in previous years. The records show that the mortality of the gipsy moth and brown-tail moth caterpillars as a result of the attack of parasites, predaceous enemies, and disease has been greater than in any of the years preceding. The experiments which are being conducted are giving information which will serve as a basis for handling infestations more satisfactorily and economically, and although new territory has been found infested the outlook for diminishing the aggregate amount of damage which results from the work of these insects is more favorable than it has been heretofore. It is necessary, however, that aggressive measures should be continued in order that the pests may be brought under better control. This is of vital importance, particularly to the citizens of States where these insects do not now exist.

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